International Journal of Information Technology and Knowledge Management
January-June 2012, Volume 5, No. 1, pp. 17-20

FAST-NCC BASED STRIP SUPER-RESOLUTION VIDEO MOSAIC CREATION

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ABSTRACT: A super-resolution mosaic image is created with the strip search logic using Fast Normalized Cross Correlation based similarity measure. It selects the manifold strips from the selected key frames which are combined to form the mosaic image. The manifold strip super resolution technique is proposed to improve the speed by memory management with task division process instead of direct super resolution of the mosaic image. The Fast Normalized Cross Correlation based similarity measure is introduced to improve the sensitivity for the strip search process. It also provides the flexibility for the strip size selection. It is also utilized in key frame selection process required in mosaic creation process. For the strip search, end strip is selected instead of strip from other locations to improve the static nature of the mosaic image. Image based Super-resolution is involved because of the use of predetermined registration parameters of required multiple replications of an image to be super-resolved to speed up the system.

Keywords: Fast Normalized Cross Correlation, Super-resolution, Mosaic, Key Frame Selection.

1. INTRODUCTION

Traditional video cameras are having limitations of horizontal and vertical visual angle. Its resolution also cannot be exceeded more than limit. It is required to think about investigation of high resolution cameras or the creation of high resolution videos from low resolution videos. Investigation of high resolution camera is more complex and its manufacturing cost is very high. Software base solution of the conversion of low resolution video to high resolution fully visualized image containing all the static information is possible by the use of mosaic technique with super-resolution operation on low resolution and static videos (video with small dynamic motions). A novel approach of super resolution mosaic image creation is proposed which is specifically designed to reduce the processing time required for super resolution methods. Super resolution of mosaic image can also be created with the direct method in which final mosaic image is super resolved with the specific super resolution method. But this way takes more processing time because of the use of large memory in the process of the large size image. The proposed method involves the slicing of the original frames into the strips and concatenation of the super resolved strips (specific strips) can form super resolution mosaic image with less processing time because of proper memory management and memory utilization into different strips processing.

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Wexler [1] used the SSD measure for searching the strip in the next few frames for its maximum match. As the SSD measure is a spatial measure, it doesn't provide the exact matching location and because of that the author has to use the single line strip for the mosaic creation. A well known Normalized Cross Correlation (NCC) [2] is utilized in our proposed work. Maximum of cross correlation coefficients provides the exact location of the match which leads to the horizontal registration. Accuracy of the Wexler's method [1] changes as the strip size is increased. But in our proposed method, it is independent of the strip size because of exact identification of maximum match points irrespective of the size with Fast-Normalized Cross Correlation (FNCC) algorithm [3].

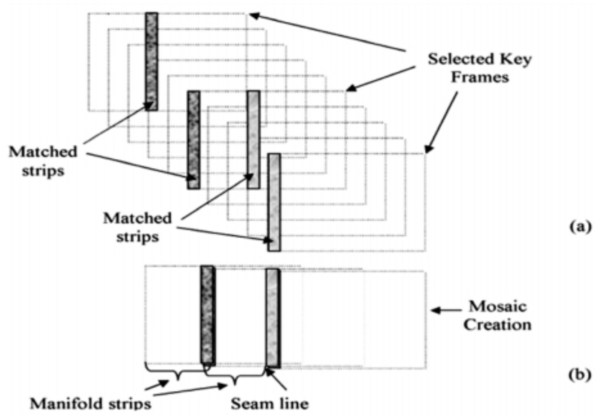

Figure 1: Time-Space Logic

The time-space logic of mosaic creation is visualized in Fig. 1(a). Under the strip search logic [4, 5, 6], mosaic image can be formed using the combination of manifold strips (Fig. 1(b)). Manifold strips are the finite size strips connected to the matched strip of the next frame. Different authors [5, 6] selected the strips of different locations for matching purposes but we selected the strips at the propagated end of the video frame because of generally not having dynamic components at the end locations which can affect the matching results.

Manifold strips of all the frames are initially super resolved. The initial frame is also super resolved and the super resolved manifold strips from next frames are concatenated to get a super resolved mosaic image.

Super-resolution can be classified as 1) Video based Super-resolution [7, 8, 9] 2) Image based Super-resolution [10, 11, 12, 13]. Video based Super-resolution includes registration of multiple frames in order to create a single high resolution frame which becomes somewhat complex to process. Instead of that, Image based Super-resolution is more suitable as it requires the creation of multiple images with known registration parameters so that it can be easily combined to get an enlarged high resolution image.

2. MOSAIC FORMATION PROCESS

The mosaic creation method requires extraction of the overlapping portion (manifold strip) between the consecutive frames of video. A similarity measure between the strips of frames is required to be defined so that it becomes more accurate to identify the exact match. On the basic of this similarity measure, Strip Search Algorithm is introduced. This algorithm can be used in Key frame Selection and horizontal Registration of strips during the process of image mosaicing as shown in Fig. 2. Proposed Mosaic method also includes Manifold Processing which has sub-processes as manifold strips extractions super resolution of the manifold strip, horizontal blending for concatenation. Manifold strip is the combination of the overlapping strips of two consecutive key frames along the estimated seam line in which the overlapping strips are striped and blended at extended portion with a horizontal blending algorithm to get single manifold strip. They are then super-resolved and concatenated with super-resolved pre-formed mosaic portion. All the processes are repeated for all the key frames to get a final mosaic image.

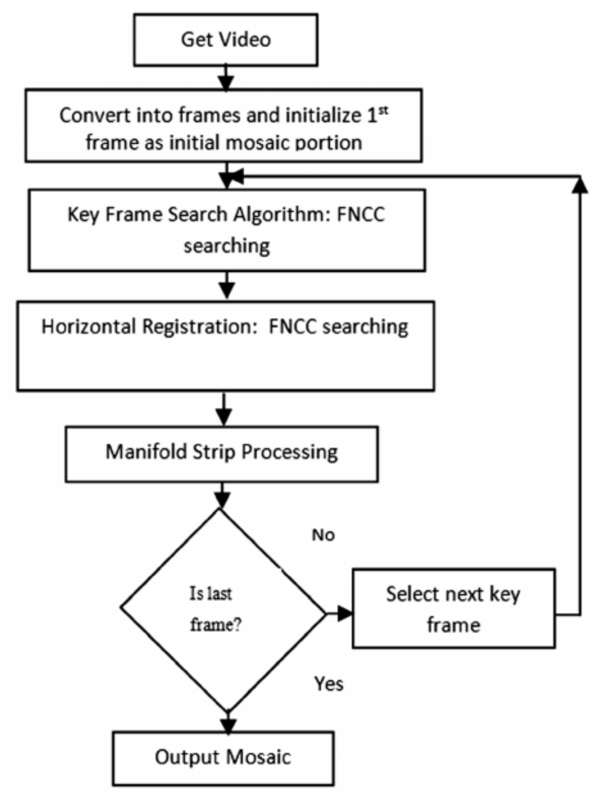

Figure 2: Flow Diagram of Mosaic Process

3. HORIZONTAL REGISTRATION USING FNCC BASED STRIP SEARCH LOGIC

Circular transformations of the frames are required for the video taken for the panoramic creation. Small strips concatenation process does not require this transformation. Video taken in horizontal propagated direction can be converted into a mosaic image with the proper horizontal registration. Rather than scanning process of strip matching [1, 4], the FNCC searching algorithm is suitable and provides faster results with the use of convolution technique [3].

The similar strip in the next key frame can be estimated from the end strip of the previous key frame with the calculation of similarity in terms of FNCC coefficients [3] (Similarity FNCC function) between the end strip si and the next N key frames f_i. The function Similarity FNCC is calculated by the equation (1) and the similarities between them over all the possible locations are modeled by using the following equation (2).

$$\text{Similarity FNCC}(A, B) = \text{maximum}(\text{FNCC coefficients}(A, B)) \quad (1)$$

Where, A and B are the two overlapped images.

$$\text{Sim}(J) = \text{Similarity FNCC}_{i=1:N}(f_i, s_j) \quad (2)$$

Location of maximum FNCC coefficient of the j^{th} frame of maximum similarity Sim (j) with the end strip of i^{th} key frame indicates the location of the estimated strip and is enlisted in datasets as indx (i),

The estimated similar strip s′ is cropped from the maximum similarity frame and given by equation (3) as,

$$\bar{f}_i = s'_{(indx(i))} \quad (3)$$

4. SUPER RESOLUTION OF MANIFOLD STRIP

Manifold strips with extended boundary are cropped and is considered for the further processing. These strips are combined in the mosaic process through Image super-resolution technique proposed by Freeman [10], which is responsible for high resolution enlarged mosaic image. It constructs a high-resolution enlargement of a given strip. Based on the framework of Freeman et al. [10], we used a regression-based approach as follows.

1. Low-resolution frames are interpolated into the desired scale.
2. A set of candidate images is generated based on patch-wise regression. Kernel ridge regression is utilized in it.
3. Patch-wise regression of output, results in a set of candidates for each pixel location. An image output is obtained by combining the candidates images based on estimated confidences for each pixel.
4. Kernel ridge regression smooth major edges and also responsible for reducing super-resolved noise in the image. The natural image prior, proposed by Tappen et al. [14] is used to preserve discontinuity at major edges.

5. STRIP STITCHING WITH THE HORIZONTAL BLENDING ALGORITHM

To address the problem of invisibility of the seam line, two registered and super resolved manifold strips are required to be stitched horizontally. A multi-resolution image stitching is utilized to get seamless stitching, in which horizontal blending across middle 3-lines is incorporated. Burt [15] first introduced multi-resolution technique which blends images using a weighted average of images. Wider range of textures can be merged with multi-resolution image compositing techniques [15]. It contributes all the pixels of overlapping width for blending purposes. Instead of that inner 3 line pixels are considered to be blend to reduce the computational complexity as we have already undergone through the exact and precise registration process. Details process of seamless blending is given through the following steps.

1. Create Laplaian pyramids of overlapping portions of two frames at different levels [16].
2. Stitch two images at every level of pyramids to get a new pyramid of blended images, along estimated seam line position with inner 3 lines.
3. The blended pyramid is expanded to get resultant blended image [16].

All these processes are repeated recursively for all the pairs of selected key frames to get high resolution panoramic mosaic image.

6. RESULTS

Time required to get a four times enlarged mosaic image using the proposed image is approximately same as the time taken to get a three times enlarged mosaic image by direct method (super-resolution after mosaic creation). This shows the fast super-resolution operation of mosaic process.

We experimented on different strip sizes with proposed strip search logic. The resultant mosaic images created are found to have non-noticeable variations.

Because of the use of the end strip of the strip search instead of other positioned strips (like centered strip), very small dynamic motions are present in final image showing static nature.

Practical experimentations are performed on the Beach Sequences with 215 frames and Boat Sequences of 524 sequences. The mosaic images without strip super-resolution and with super-resolution are shown in Fig. 3 to Fig. 6.

Figure 3. Mosaic Image Without Strip Super-Resolution of the Beach Sequences

Figure 4: Mosaic Image with Proposed Strip Super-Resolution of the Beach Sequences

Figure 5: Mosaic Image Without Proposed Strip Super-Resolution of the Boat Sequences

Figure 6: Mosaic Image with Proposed Strip Super-Resolution of the Boat Sequences

7. CONCLUSION

About 75 % speed is improved with proposed a strip super-resolution mosaic method with respective to the direct method. FNCC based similarity measure works well to get the desired results. Algorithms like Key Frame Selection, Image based Super-resolution and Horizontal Blending Algorithm are found suitable and responsible for the fast, accurate and seamless mosaic image from the video propagating in horizontal direction.

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